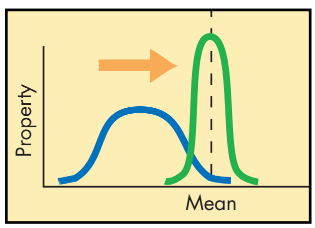
Models ensure lighter weight chassis components with fewer defects

O A A T   A C C O M P L I S H M E N T S

Improved Cast Lightweight Metals

Challenge

Cast lightweight metals, like aluminum and magnesium, can replace cast heavier metals, like iron and steel, in selected vehicle structural parts. To be effective substitutes, cast lightweight metals must offer similar properties and performance to their heavier counterparts and comparable costs to manufacture. Castings tend to be inherently flawed with variable properties (e.g., tensile strength, fracture strength, ductility), requiring designs to be anchored around the poorest known performance of a particular property. These designs waste materials and increase weight. More precise knowledge of castings properties could enable designs that reduce materials usage and weight.



Reduced material property variation combined with an increasing mean leads to lower cost and weight.

Technology Description

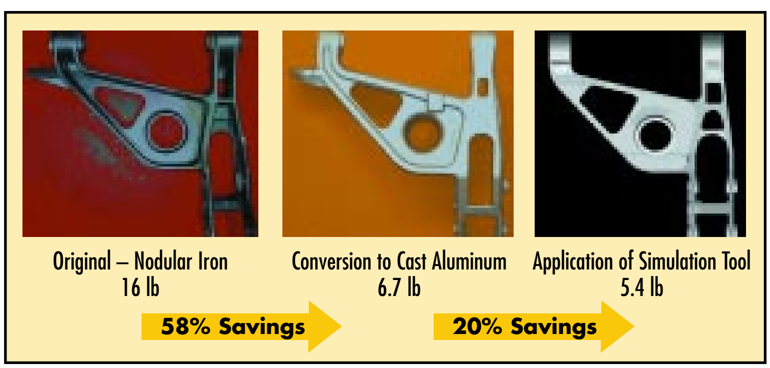
This program developed new models and process monitoring technologies that ensure more repeatable casting results. Design engineers, armed with a more precise understanding of the properties of cast materials and an improved ability to control casting processes, are able to construct lighter-weight cast chassis components.

Computer models developed to predict microstructures of cast aluminum A356.0 based on casting parameters, have been linked to models which predict mechanical performance based on microstructures. These links enable more precise prediction of material properties (narrower distribution of variable properties) and design of cast components to tighter tolerances. An understanding of how microstructure affects mechanical properties also allows designers to add weight only where necessary and trim weight where it is not. This results in lighter-weight components with fewer defects.

Rapid response temperature sensors monitor the casting process to ensure product integrity and minimize defects. Non-destructive evaluation (NDE) techniques ensure that the lighter-weight cast component meets all requirements for mechanical properties.

Accomplishments

The program developed a comprehensive material property database for cast lightweight metals based on the behavior of microstructures. The database is driven by samples excised from production aluminum castings and magnesium high-pressure die castings, and incorporates historical aluminum and magnesium material property data. Property database information, lessons learned from successful applications, and industry input were combined to produce new design guidelines for cast lightweight metal structural components.



Component weight reduction.

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The first product of this program is a lightweight aluminum structural support arm. The weight of the original structural support arm made of nodular iron was reduced by 58% when manufactured, in identical form, to cast aluminum. An additional 20% reduction in weight was achieved when the cast aluminum arm was redesigned using the insights from the material property database. The new design not only made the cast aluminum arm cost competitive with the original nodular iron arm, but recouped a total 78% weight reduction, while equaling or bettering the arm's mechanical properties.

To ensure cast component consistency and quality, the program also developed on-line process monitoring, feedback control, and NDE techniques.

Benefits

Reduction in vehicle weight lowers energy consumption and correspondingly lowers emissions. For each percent reduction in vehicle weight, relative to the total vehicle weight, there is about a 0.6-0.8 percent gain in energy efficiency results. Technology developed in this program will hasten the cost-effective application of light metal structural castings and support the vehicle mass reduction targets of the Partnership for a New Generation of Vehicles (PNGV).

The program also reduces alloy, supplier handling, and testing manufacturing costs for cast light-weight metals to make them more competitive with heavier metal components.

Commercialization

- DaimlerChrysler Corporation, Ford Motor Company, and General Motors Corporation are using the information in the material property database to design new components.
- Models developed to predict cast microstructure and mechanical properties have been incorporated into commercial software packages.
- Infrared fiber-optic sensors developed by the program are being used in industry production equipment.

Future Activities

The fruits of this work on cast aluminum components will be extended to magnesium applications. The majority of magnesium components that are cast today are made by the high-pressure die casting process. This program will investigate other methods of producing magnesium automotive components.

New models will be developed to predict microstructures and mechanical properties. In addition, the existing database will be expanded: New design rules will be developed and new NDE techniques will be evaluated.

Partners in Success

- American Foundrymen's Society
- DaimlerChrysler Corporation
- Entelechy
- Ford Motor Company
- General Motors Corporation
- Georgia Tech University
- Intermag
- Lawrence Livermore National Laboratory
- Oak Ridge National Laboratory
- Sandia National Laboratories
- The Aluminum Association
- Westmoreland Mechanical Testing and Research
- 32 small- to medium-sized automotive casting suppliers